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AN ADDRESS
ON
EVOLUTION AND THE PATHOLOGICAL IMPORTANCE
OF LOWER FORMS OF LIFE.

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Delivered before the Graduating Class of the Medical Department of
the University of Pennsylvania, May 1, 1886.

REPRINTED FROM THE THERAPEUTIC GAZETTE FOR JUNE 15, 1886.

DETROIT, MICH.:
GEORGE S. DAVIS, PUBLISHER.
1886.



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GENTLEMEN :—I open my topic with an asseveration from the “Cosmic Philosophy” of that clear thinker, John Fiske, of Cambridge, “There is a Power to which no limit in time or space is conceivable, and all phenomena are but manifestations of that one eternal and infinite power.” It is this Power which is everywhere recognized as God, whose existence is proclaimed as the Supreme Truth alike by science and religion.

The genesis or original production of life is directly attributed to God, but the manner of its creation has always been and still remains a mystery. With the introduction on earth of a primitive form, or kind of living being, science is prepared to explain the subsequent production of all others, which, from the remotest period through successive ages down to the present time, have exhibited an infinite number of kinds of the most variable degrees of complexity, culminating in man and his contemporaries. The explanation is



found in the doctrine of the evolution of life, which is in accordance with the general law of evolution as propounded by that greatest of philosophers, Herbert Spencer. This general law, like that of gravitation, appears to apply to everything, and as the planetary system seems to have been evolved from ancestral nebulæ, so all existing forms of life appear to have been evolved from organic dust, as first clearly set forth by that profound naturalist, Charles Darwin, who has recently left us, we may hope, for a still higher evolution.

According to the doctrine of the evolution of life, living beings have been derived from one another, the most complex and highest forms of plants and animals being the slowly modified descendants of less complex plants and animals, while these were the slowly modified descendants of still less complex forms, and so on until we go back to the earliest and simplest plants and animals.

The agencies by which the process of evolution is carried into effect are of the kind we daily observe in operation around us, as the incessant individual variation in plants and animals, their adaptation to environing conditions, and the hereditary transmission of acquired individual peculiarities.

The prevailing hypothesis of the origin of living creatures in all time, and still maintained by the greater but generally less informed and less thoughtful portion of society, is that each and every species of plant and animal was a special or direct creative act of the Creator. Thus, in illustration, it is considered that each and every species of oak

and pine, of fish and bird, was a direct act by which it appeared in space independently of any pre-existing form. Those adopting the law of evolution see in all races of men one brotherhood, while those holding the doctrine of special creations, like the late Prof. Agassiz, are driven to the necessity of regarding each race as a distinct and separate creation.

The first revelation of the law of the evolution of life startled people from a revery. The doctrine for a time was accepted by few, and even reluctantly or with qualification by some of these, but generally it was rejected, pronounced incredible and absurd, and frequently became the subject of ridicule. Many, without reflection, made their feelings an objection to the theory ; and even a distinguished professor of the Jardin des Plantes, of Paris, in a public lecture, thought he was using a powerful argument against it when he contemptuously stated that neither he nor his audience wanted an orang for their grandparent.

The reception of new theories, or systems intended to convey general truths, has always been the same, and men never seem to be prepared for any unusual disturbance in the habit of thought. When Newton announced the law of gravitation, people objected to it, for they regarded it as a denial of God's control of the movements of the universe ; and when Franklin suggested the use of the lightning-rod, it was denounced as an impious attempt to deprive the Deity of his thunderbolts. Often, to be sure, hasty judgment leads to false theories, but should the theory be true, sooner

or later, despite all obstacles, it is accepted and added to the common stock of knowledge.

Time for due consideration and reflection, together with many new observations and discoveries in biology bearing on the subject, tend more and more to confirm the theory of the evolution of life, and I believe the doctrine is now sustained by most distinguished naturalists, and is accepted by a large portion of the educated and thinking community.

While the special creation of living beings cannot be clearly realized in thought, the production of the most complex and highest forms from the lowest and simplest forms, through the slow accumulation of change upon change, and by slow divergences which result from the continual addition of differences to differences, is readily conceivable. In like manner, as we may observe improved and conspicuously marked varieties of useful plants and domestic animals derived from inferior stocks through appropriate management, we can see that under similar conditions the various species of animals and plants now existing may have been derived from nearly allied forms of the age immediately preceding the present age. In this manner, for example, we can comprehend how, by gradual modification, the living species of elephants are the descendants of the nearly allied extinct species; and how our domestic horse and ass are the successors of a three-toed ancestor which has ceased to exist. While such a view of the origin of animals appears probable and clear, it seems impossible to realize how they could come into existence from empty space.

Withal, the law of the general evolution of life is not so extraordinary as is commonly supposed, and is really no more wonderful than the special evolution we observe incessantly going on around us in the development and growth of every individual plant and animal. The earliest manifest germ of each seed and egg is a single microscopic cell, from which in a little space of time is evolved each and every form of living being, including man himself. Surely, then, if a single, simple organic cell shall, in the course of a few days, months, or years, result in the production of a moss, an oak, a worm, a fish, or a man, there certainly can be no improbability that a like cell, in the course of untold ages, may have been the ancestor of all existing forms of living beings. The infinite and mysterious power of the Creator is alike manifest in the development of each and every seed and egg, in the evolution of each and every specific form of life, and in the original production of that primitive and lowly form from which all other forms have been derived.

In the production, growth, and development of living bodies, the ultimate chemical elements of structure are derived from the mineral kingdom, where they compose the earth, water, and atmosphere. Living bodies are, however, composed from complex combinations of these elements, which originate in a common material which does not pre-exist in the mineral kingdom. This common material, named protoplasm, is distinguished as the physical basis or substratum of organization. It is a complex definite compound

of the gaseous elements of the air and water with the solid elements carbon and sulphur. I repeat that it is nowhere to be found in the mineral kingdom. The skill of the chemist has failed to produce it, and science knows no efficient cause for its production other than God.

The amount of protoplasm required in the construction of organic bodies is enormous, is incessantly consumed in the requirements of life and in the death of living bodies, and is as incessantly renewed. What is the source of all this protoplasm?

Science has discovered the fact that protoplasm is produced under the influence of the solar ray in the green plant, which manufactures it from inorganic elements, chiefly water, carbonic acid, and ammonia. The animal takes no part in its production, but, on the other hand, consumes it, and returns the inorganic elements to their original source. Every tiny chlorophyll ball is a laboratory for the production of protoplasm, starch, and other important organic materials, and thus it is that the bright green verdure of the earth, which so delights the eye, is the common source of the material which is the basis of all organization. Though the sun is distinguished as the source of life, it is only one factor in its production, and would be powerless to this effect without the green plant endowed with special attributes by its Creator. All green plants are immersed in their food, the air, water, and earth, and hence they are commonly fixed or rooted to their place of birth. Animals, powerless to produce the material of their composition, are endowed with

locomotive power to enable them to apply to the fixed plant for their food, or to wage war and prey upon one another for the same purpose.

As the only direct source of protoplasm is the green plant, it necessarily follows that in the order of origin this must have preceded the animal, and if we admit the doctrine of the evolution of life, of the highest from the lowest forms, the simplest of green plants is the all-sufficient element for the production of all organic forms.

An ancient and still prevalent doctrine among naturalists, philosophers, and others holds the theory that the beginning of life proceeded from the waters. The facts of science go to show that the green plant, which in its origin preceded the animal, finds the most favorable conditions for its life in a moist atmosphere and in bright sunlight. Few green plants grow in the ocean waters below one thousand feet, and none below double that depth. In the language of the Bible, after the waters were "gathered together" and the "dry land" appeared, *then* "the earth brought forth grass." This seems better to accord with the condition most favorable to the production, development, and continued evolution of life. At the boundary of the islands or continents, as they emerged from the waters, the earth was maintained in a moist condition by the proximity of the ocean, and there the influence of the sun was all that was required in the production of the material basis of life.

In accordance with the doctrine of the evolution of life and its known conditions, we

may reasonably infer that the first living being was the simplest green plant, which also may continue to exist in its original primitive form in our day. The law of evolution does not imply the necessity of change or transformation of the primitive form. While the process may go on under a change of circumstances, and many of the new forms undergo transformation after transformation, advancing in complexity, and acquiring new habits and capacities, others, from the first, or after more or less progress, may deteriorate, become degraded, or dwindle away and become extinct, while others, again, may retain their original form, or any subsequent one, through all future time.

As illustrations of advancement even to a highly complex organization, and a subsequent retention of the form without manifest change through successive ages, we may refer to the animal *lingula*, whose remains are found in the Lower Silurian rocks, composed of the sediments of the ocean, and estimated to have been deposited millions of years ago, but which yet lives, apparently unchanged, on our Atlantic shore to-day. Likewise, the roaches and the scorpions of our time have their recognized ancestors in the ancient coal-bearing rocks; and the fish *ceratodus*, originally made known to us by Prof. Agassiz, from remains in the Jurassic and Triassic rocks, has recently been found, living in the muddy streams of Queensland, Australia.

Among the almost endless variety of living forms now existing is there one which answers all the conditions required by the law of evolution, and which may be recognized as the

first-born of creation and that from which all subsequent forms of life have sprung? I repeat that if a single, microscopic cell, the germ of the seed or egg, under the usual appropriate conditions, shall, in the course of a brief space of time, end in the development or production of an oak or a man, there is certainly no improbability that a similar cell may have in the course of ages resulted in the evolution of all existing forms of living bodies.

The first-born of creation, I conjecture, we may recognize in the tiny green plant described by botanists as the *protococcus viridis*. It grows all over the world in the presence of a certain amount of moisture, warmth, and sunlight ; and under these conditions is everywhere observed in shaded places, appearing like a coat of green paint on the north side of tree trunks, rocks, walls, fences, pavements, and the earth. Each individual plant is a single microscopic, spherical cell, enclosing a mass of chlorophyll, and it incessantly and rapidly multiplies by growth and segmentation. Readily detached from its position in the dried state, it is scattered as dust by the winds, and, when deposited in favorable positions, it is instantly restored to activity, and again reproduces itself.

In this most humble of green plants—the *protococcus*—we have the original type of life, if not actually the first-born of created beings. A simple plant, endowed with the same wonderful capabilities of every seed and egg, it has been the progenitor of all succeeding forms of life, both plant and animal, culminating in man. The suggestion

that protococcus is the first-born of created life and the progenitor of all subsequent forms to the highest, will no doubt excite a smile of incredulity ; but if we admit the law of evolution of life it cannot be disputed that it is the all-sufficient element in the process. To Raspail, the French chemist, it furnishes the cell with which, if he were supplied, he said he could build up the whole organic world. In the evolution of life, protococcus is the first manifest step which accords with the declaration that "God formed man of the dust of the ground." I may add that in this we may see an illustration that between Science and Religion there is no conflict. It is in the interpretation of facts rather than in the facts themselves that the difference chiefly consists. The shield is altogether of silver or altogether of gold, as it is viewed from the one stand-point or from the other, but, after all, it is the same shield.

In the course of the evolution of living beings, a multitude of inferior organisms have come into existence, which prey upon superior organisms, are more or less hurtful or destructive, and are the chief causes of disease, suffering, untimely death, and decay. In regard to these consequences, Mr. Spencer remarks, that "if, in the uniform working out of the process, there are evolved organisms of low types, which prey on those of higher types, the evils inflicted form but a deduction from the average benefits. The universal and necessary tendency towards supremacy and multiplication of the best, applying to the organic creation as a whole as well as to each species, is ever diminishing the damage done,

tends ever to maintain these most superior organisms, which in one way or other escape the invasions of the inferior, and so tends to produce a type less liable to the invasions of the inferior. Thus, the evils accompanying evolution are ever being self-eliminated. Though there may arise the question, Why could they not have been avoided? there does not arise the question, Why were they deliberately inflicted? Whatever may be thought of them, it is clear that they do not imply gratuitous malevolence." (Prin. Biol., i. 354.) Of the inferior organisms which are detrimental to the superior organisms are the numerous animal parasites of other animals, generally belonging to the class of worms, and called entozoa, from their living within animals, or intestinal worms, from the usual position in which they are found. Frequent and distressing, and often fatal, as are parasitic animals, they are far exceeded in subtle character, and in dangerous and destructive qualities, by the fungi. These are familiarly known as mushrooms, toadstools, moulds, mildew, rust, smut, and rot, and are relegated by the biologist to the vegetable kingdom, though they greatly differ in appearance, habit, and capability from green plants. They neither feed in the same manner as the latter, nor are they direct manufacturers of the chief organic elements. They prey on dead or dying plants and animals and their products; they are the ghouls of the organic world,—thugs concealed in darkness, and ever on the alert to strangle the traveller. As bacteria, they constitute the most degraded forms of living beings, and at the same time are the

most potent agents in the production of pestilence, death, and decay.

Until recently fermentation and putrefaction were considered to be due to the exposure of organic substances to the combined influence of moisture, warmth, and air, but it has now been determined that the direct agents in these processes are microscopic fungi floating in the atmosphere, and that they will not occur without the presence of these organisms. Ordinary fermentation, as in the production of beer, wine, and other spirituous liquors, is due to the growth and reproduction of the yeast-fungus, *saccharomyces*, which decomposes the sugar present in the vegetal juices and converts it into alcohol and carbonic acid. The souring of fermented products, and their further changes, are due in like manner to the presence of other fungi. The putrefaction of meats, with its attendant disagreeable odors, is caused by the bacterium *termo*, and does not take place when access of this fungus is prevented. The decay of wooden buildings and other structures of timber is ordinarily due to fungi, commonly known as "dry rot," and consisting of species of *merulius* and *polyporus*. The blights, mildews, smuts, and rusts which are such enemies to the agriculturist, destroying his grain, fruit, and other vegetal products, are all fungous parasites.

Most wonderful and frightful is the power for evil of these corsairs in the sea of life. Differing in well-marked and decidedly important characters from green plants on the one hand, and animals on the other hand, they may be regarded as forming a third and

distinct kingdom of organic bodies. Only lately we have learned of a new phase in their career in relation to green plants, not destructive as usual, but in habit reminding us of the system of slavery previously observed only with man and certain species of ants. The researches of botanists now make it appear that the group of plants named lichens, those dry, gray crusts and threads which grow on the dead bark of trees, old timbers, rocks, and otherwise sterile grounds, are parasitic fungi, which entrap green algæ, like protococcus, and hold them in their toils while they feed on the products of their labor, the enslaved algæ in the mean time pursuing their ordinary course, and multiplying, as formerly among our own kind did the slave families of men.

Aside from the too familiar fact that man and other animals are infested with entozoa which produce more or less inconvenience and distress, and frequently disease ending in death, it has been made obvious to us in our time that more serious and wide-spread diseases are due to fungous parasites. Indeed, it is now the prevailing idea that most if not all infectious and contagious diseases are of parasitic origin. Various forms of microscopic fungi, of the order of bacteria, exemplified by the genera micrococcus and bacillus, have been discovered to be constant attendants on such affections, and in many instances have been demonstrated to be the agents by which the diseases are conveyed.

Louis Pasteur, the renowned French chemist and skilful investigator, on whom the eyes of the whole world are now directed on ac-

count of the thoroughness and success of his researches into the causes and prevention of some of the gravest diseases which afflict our race, declares that it is in the power of man to completely sweep parasitic diseases from the face of the earth. Perhaps the declaration may be too strong, yet it seems that the demonstrated facts are already sufficient to make us hopeful that we are on the threshold of discovery, by which we shall be enabled to bring the agencies of these diseases so far under control as to render them of no greater detriment than the ordinary accidents to which we must always be more or less liable.

A few significant facts may be mentioned in evidence that our expectations and hopes are neither visionary nor even exaggerated.

Only fifty years ago nothing was positively known as to the manner in which man and inferior animals became infected with parasitic worms. While the conviction of many was that all forms of living things were derived from parents, as expressed in the axiom *omne vivum ex ovo*, others openly or tacitly admitted their existence as evidences of the hypothesis of spontaneous generation. Well do I remember the time when an able teacher expressed the opinion that a shred of fibrin or mucus under certain morbid conditions might be transformed into a tapeworm; and another considered that maceration in water was sufficient to convert a horse-hair into a hair-worm or gordius. Since then many able investigators have most indubitably proved the doctrine that all organic forms, the simplest as well as the most complex, originate alone from parents. We have learned that

parasitic worms, like ordinary insects, flies, butterflies, and beetles, pass through entirely different forms in different stages of their life, and that the different stages are passed in different animals into which they gain access through the food and drink. With these discoveries we have also learned the sure method of controlling and preventing the invasion of parasitic worms. By the proper cooking of food and the boiling or filtration of drinking water any parasites which may be present are destroyed, or prevented from entering the person they would otherwise infect. Man, perhaps unintentionally, has been freer from parasitic worms than most other animals, from the peculiar habit of using fire in the preparation of food, though he is often yet too careless in the employment of this agent, and thus frequently becomes the host of disagreeable or dangerous guests introduced through half-cooked meats.

I recall to mind an occasion upwards of forty years ago, while I was a student assisting my preceptor, Dr. Goddard, then demonstrator of anatomy in the University, and professor to Prof. Horner. We were making preparation for a lecture on the muscles, when Dr. Goddard, who was endowed with quick perception and sharp vision, observed an appearance in the flesh which led him to examine it with the microscope. In it he found a number of minute, coiled worms, to which he called the attention of Prof. Horner. The parasite had been discovered a short time previously by the English surgeon, Sir James Paget, and was described by Prof. Owen, with the name of *trichina spiralis*. Several years

later I found the same parasite in pork. Then, and for some time subsequently, no significance was attached to the occurrence of trichina as a parasite, and if you will refer to any medical dictionary published twenty-five years ago, you will find the worm mentioned, but no intimation of its relation to a grave disease which has since been recognized, but was then not even suspected. Now we are well informed of the parasitic affection trichinosis, caused by trichina, introduced into our body in pork, a meat which was declared to be unfit for food, thousands of years ago, by the great law-giver Moses. While trichina has been dealing death and destruction to our kind from the most remote times, until recently its existence was unknown, but having discovered it, we are now able to prevent its effects. As an example of its dangerous character, in a recent statistical account of trichinosis in Saxony, we read that in fifteen years, from 1860 to 1875, there were 39 epidemics of the affection, and 1267 cases with 19 deaths. We now have the trichina completely under control, and no one need run the risk of infection. By thoroughly cooking pork any parasites that may be present will be destroyed, and thus prevented from doing injury, and it may be added that by the process of cooking the pig ceases to be unclean food. The relation of such facts need and should not prejudice you against the use of pork as food, for all animals employed for the same purpose are likewise liable to be infected; but the cardinal rule should be observed that all meats, or such especially as have been recognized or are suspected to be liable to

harbor troublesome or dangerous parasites, shall be cooked, by which process the parasites are rendered innocuous. Fire is the great purifier of food and water, and if it could be as readily applied to the air we breathe, we would in a great measure be able to get rid of all parasitic affections.

After the researches of Schwann and Pasteur had clearly proved that bacteria were the cause of putrefaction, Joseph Lister, the distinguished English surgeon, was led to regard the same organisms, introduced into wounds, as the cause of mortification, which so often defeats the object of the most skilful operator, and frequently destroys the patient. In this view he devised means for preventing the access or destroying these destructive organisms, and thus established that antiseptic system of surgery which is, as remarked by John Tyndale, one of the greatest and most beneficent achievements of our age.

In 1853 the silk-culture of France in value was estimated at twenty-five million dollars, but, as the result of a malady which affected the silk-worm, in two years afterwards fell to five million dollars. Pasteur, having been requested by the Minister of Agriculture to undertake the investigation of the disease, which is called pebrine, determined it to be due to an exceedingly minute fungus parasite, a species of micrococcus. He proved that the germ might be present in the worm and in the egg and yet elude the search of the microscope. In the moth the fungus reaches a degree of development so distinct as to render its detection inevitable. From healthy moths, healthy eggs were sure to spring, and from

these vigorous worms ; and thus, by making the proper selection, the problem of restoring to France its former prosperity in silk husbandry was established.

In his researches on pebrine, Pasteur inquired how the disease was spread, and pursued the inquiry in the only manner that was open to him. He infected healthy worms, by smearing mulberry-leaves, their food, with material containing the fungus. He also infected them by inoculation, showing how they infected one another by scratches of their claws. Bringing together healthy and diseased worms, the healthy ones, like their smitten companions, soon sickened and died. He produced infection at a distance by wafting the fungus dust through the air. All the modes by which infectious diseases may be spread among human beings were thus illustrated. Here, I may add, we have also an illustration of the benefit that is to be derived from judicious experiments on living animals. Admitting that it was for the moment cruel to treat the healthy silk-worms in this fashion, it is clear that Pasteur's investigations swept a deadly epidemic from the soil of France, and for the units slain during the experiments millions have been preserved.

Splenic fever, or anthrax, an extremely fatal affection of cattle, was determined by the celebrated German physician, Dr. R. Koch, to be due to a bacterial parasite, the bacillus anthracis. * Pasteur being led to investigate this disease has also discovered the means of preventing it. This is done by inoculating the animals liable to infection with a liquid containing the bacillus, which, by a

process of treatment, has lost its virulence, and yet enables the animals inoculated to effectually resist the attacks of its more potent parent.

Hog and chicken cholera, equally destructive to the animals affected, have also been ascertained to be caused by similar bacterial parasites, and are now successfully treated in the same manner.

A micrococcus is the constant associate and cause of smallpox, and, as is well known, this dreadful disease has for a long time been in a great measure prevented by vaccination. In this treatment the same parasitic organism renders powerless the venom of its parent. Last, and not least, we now receive daily notices that that fearful malady, hydrophobia, also reputed to be caused by a bacterial parasite, has been brought under control by the great Pasteur.

Gentlemen, those of you who have chosen the responsible calling of the physician, and are now each of you, by title, doctor in medicine, we, your teachers, this day bear witness, before the trustees of the University and our fellow-citizens here assembled, that you are duly qualified to enter on the duties thereto belonging. By this calling you engage to take charge of the health of the community, to treat diseases and remedy accidents, or alleviate their pain and distress, and to save your fellows from untimely death. For this you are to expect and should receive due compensation for your services, or, in other words, you will practise your profession as a livelihood. Bear in mind, however, that it is not for this alone you are to labor, for the

principles of the medical profession require you to do all in your power to promote the general health of society, even though there be no expectation of return other than that which arises in the common welfare. To the extent of your ability you should also exert yourself in the investigation of diseases with the view of preventing them. To no profession so much as ours does the altruistic sentiment apply, "Love thy neighbor as thyself;" and it is with a feeling of pride that I express the belief that no profession more than ours lives up to this precept, for no body of men are more self-sacrificing for the good of others than are physicians. Statistics show that the war against disease is attended with no trifling risks, and that those who fight this battle are exposed to chances of death above those incurred by nearly all their fellows. In the conviction that you are prepared to assume the duties and responsibilities of the medical profession, I would urge you to emulate its great spirits, its zealous workers, and its earnest searchers after truth and the common good of mankind.

It has mainly been under the advice and guidance of the medical profession that governments, societies, and benevolent citizens have established and supported hospitals and other asylums for the sick. Still further to promote the health and common welfare, I feel that it is incumbent on us to advise and urge our government to appoint and maintain a sufficient corps of the most able physicians and skilful observers and experimenters, whose function it shall be to investigate all the causes of epidemic, contagious, and infectious dis-

eases which affect man, domestic animals, and useful plants, with the view of determining means for their destruction or for preventing their action. Something, to be sure, has already been done in this way, and with such conspicuously beneficial results that we are encouraged to further effort to the utmost in the same direction. Until recently almost nothing was done to ascertain the causes and mode of prevention of diseases, and it was and still is customary to await their attacks, and then depend on drugs to exorcise them. Posterity, I apprehend, will look back with wonder at our apparent apathy and neglect in awaiting the invasion of epidemics and at our faith and dependence on the fetiches of medicine to destroy them.

On this theme I would like to dwell and say more, but our time is short and I must forbear.



